Unit 2
Cells

Chapter 4: A Tour of the Cell

Prokaryotes vs and Eukaryotes

- Basic features of all cells:
  - Plasma membrane
  - Semifluid substance called **cytosol**
  - Chromosomes (carry genes)
  - Ribosomes (make proteins)
- Differences include:
  - Location of DNA
  - Size of cells
  - Internal organization

- **Prokaryotic cells** have
  - No nucleus
  - DNA in an unbound region called the **nucleoid**
  - No membrane-bound organelles
- **Eukaryotic cells** have
  - DNA in a nucleus that is bounded by a membranous nuclear envelope
  - Membrane-bound organelles
- Eukaryotic cells are generally much larger than prokaryotic cells

- The ratio of surface area to volume of a cell is critical!
  - Small cells have a greater surface area relative to volume
  - Larger organisms do not generally have *larger* cells; they have *more* cells
  - Microvilli increase surface area without an appreciable increase in volume

Figure 4.4

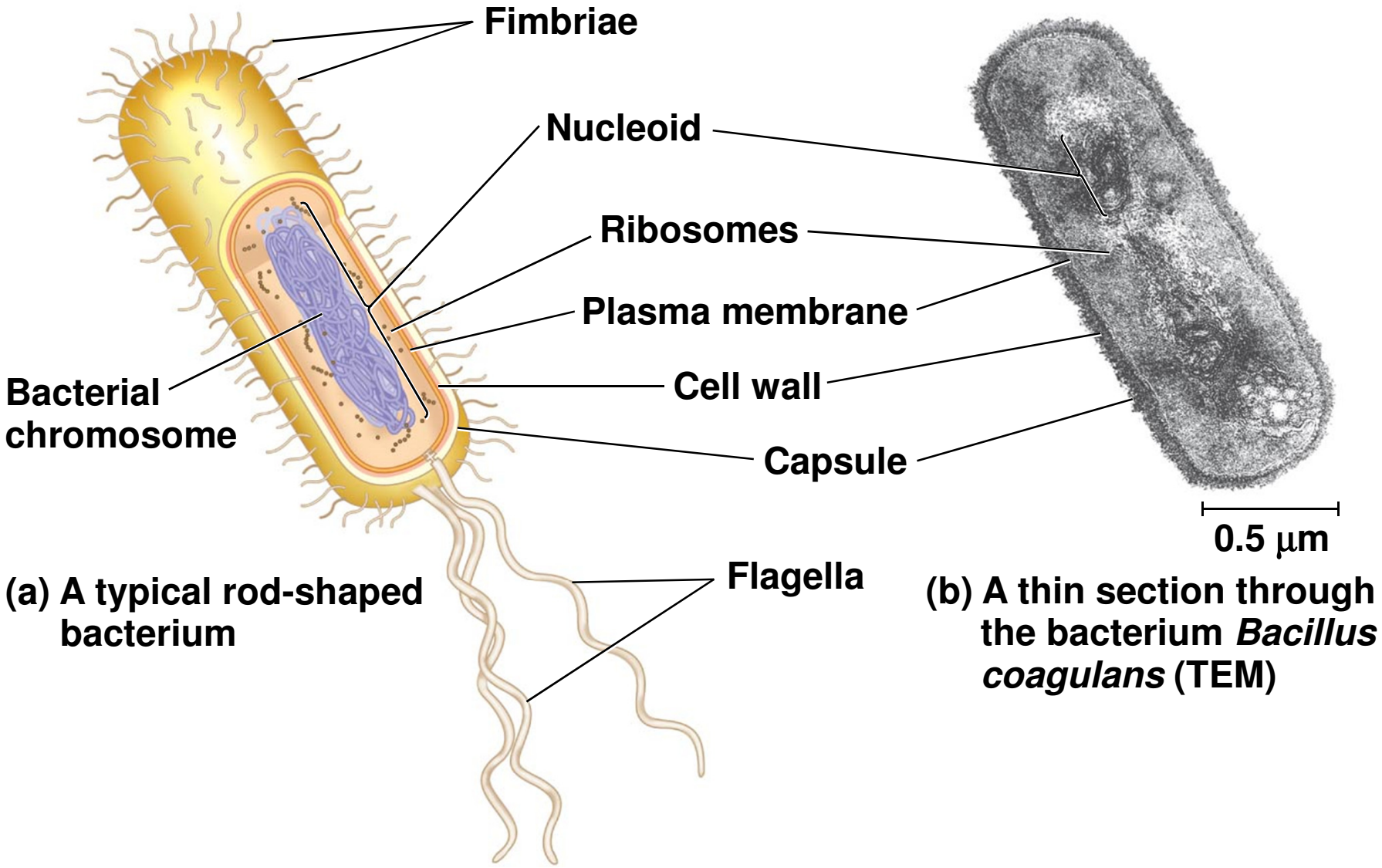

Fimbriae
Nucleoid
Ribosomes
Plasma membrane
Cell wall
Capsule
Bacterial chromosome
Flagella
0.5 μm
(a) A typical rod-shaped bacterium
(b) A thin section through the bacterium *Bacillus coagulans* (TEM)

Figure 4.7a

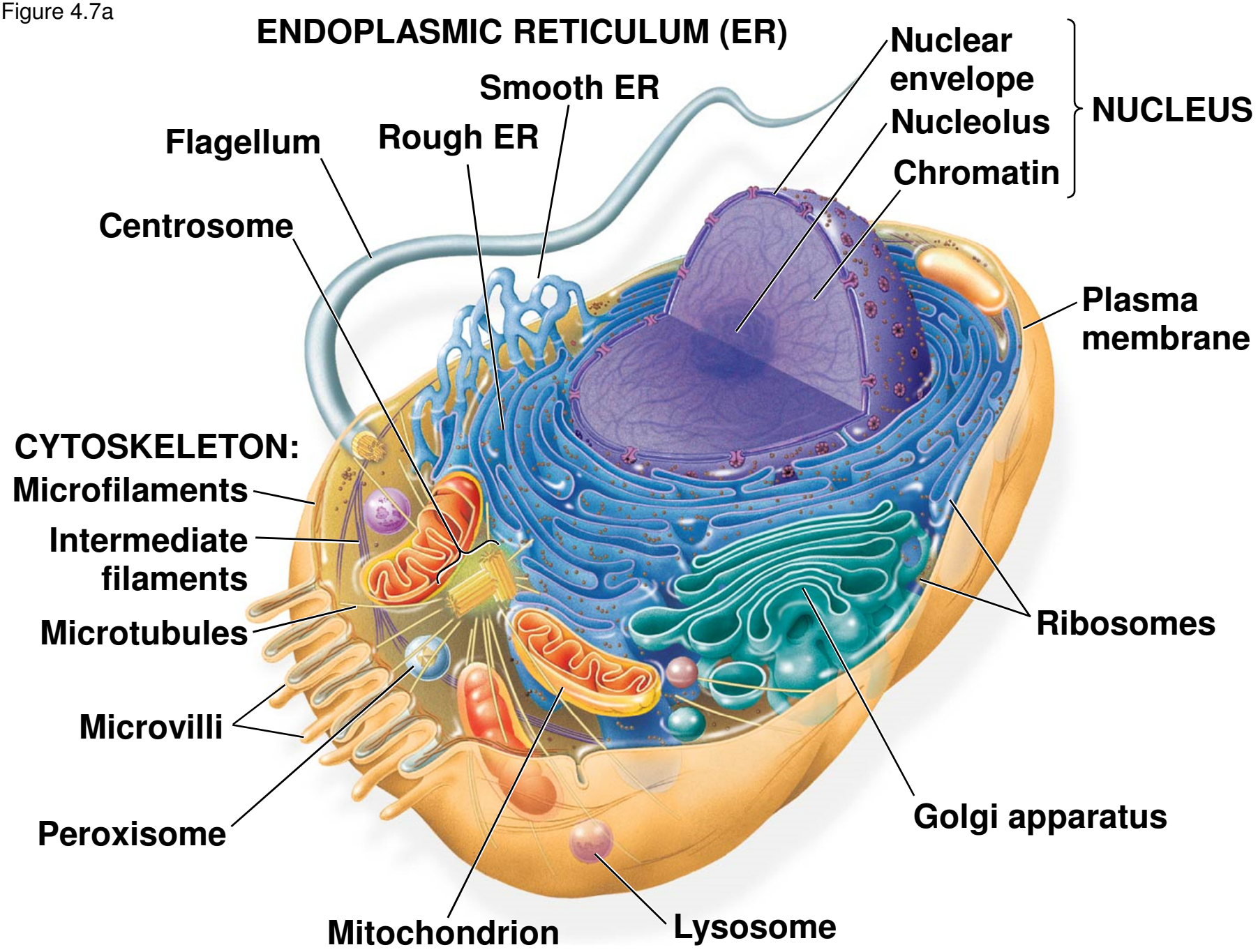
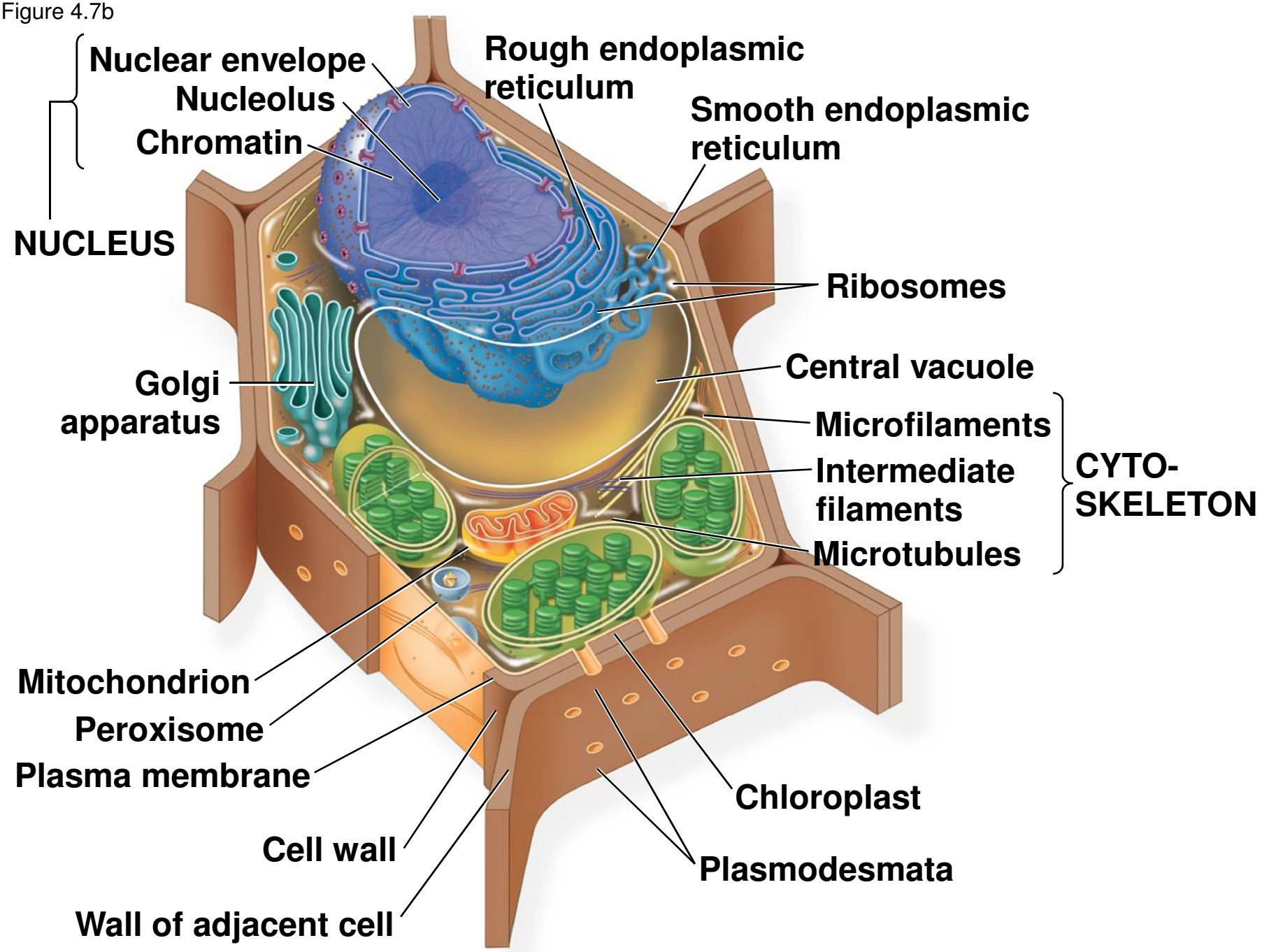

ENDOPLASMIC RETICULUM (ER)
Smooth ER
Rough ER
Flagellum
Centrosome
Nuclear envelope
Nucleolus
Chromatin
NUCLEUS
Plasma membrane
CYTOSKELETON:
Microfilaments
Intermediate filaments
Microtubules
Microvilli
Peroxisome
Mitochondrion
Lysosome
Ribosomes
Golgi apparatus

Figure 4.7b


Nuclear envelope
Nucleolus
Chromatin
NUCLEUS
Rough endoplasmic reticulum
Smooth endoplasmic reticulum
Ribosomes
Golgi apparatus
Central vacuole
Microfilaments
Intermediate filaments
Microtubules
CYTO-SKELETON
Mitochondrion
Peroxisome
Plasma membrane
Cell wall
Wall of adjacent cell
Chloroplast
Plasmodesmata

Organelles

- The **nucleus** contains most of the DNA (organized into chromosomes) in a eukaryotic cell
- **Ribosomes** use the information from the DNA to make proteins
- The **endoplasmic reticulum (ER)** is a network of membranes continuous with the nuclear envelope
  - **Smooth ER**: lacks ribosomes
    - Synthesizes lipids, metabolizes carbohydrates, detoxifies drugs and poisons, stores calcium ions
  - **Rough ER**: surface is studded with ribosomes
    - Membrane factory for the cell, distributes transport vesicles

- The **Golgi apparatus**
  - Modifies products of the ER
  - Sorts and packages materials into transport vesicles
- **Lysosomes** contain digestive enzymes that breakdown macromolecules and organelles
- **Vacuoles** store water and organic compounds
- **Peroxisomes** contain enzymes that remove hydrogen atoms from certain molecules and transfer them to oxygen, producing hydrogen peroxide
  - Detoxify alcohol and other harmful compounds

- **Mitochondria** are the sites of cellular respiration
  - Metabolic process that uses oxygen to generate ATP
- **Chloroplasts**, found in plants and algae, are the sites of photosynthesis
  - Convert solar energy to chemical energy
- Mitochondria and chloroplasts have similarities with bacteria (**endosymbiont theory**)
  - Enveloped by a double membrane
  - Contain free ribosomes and circular DNA molecules
  - Grow and reproduce somewhat independently in cells

- The **cytoskeleton** is a network of fibers extending throughout the cytoplasm
  - Important in support and motility
  - Centrioles = facilitate movement of chromosomes during cell division
  - Cilia and flagella = movement
  - Actin and myosin = muscle contraction

Extracellular components

- **Cell wall**
  - Found in plants**,** prokaryotes, fungi, and some protists but NOT animals
  - Protects cell and maintains its shape
- Animal cells lack cell walls but are covered by an elaborate **extracellular matrix (ECM)**
  - Important in cell to cell communication

Cell Junctions

- Plants
  - **Plasmodesmata**
    - Channels that perforate plant cell walls through which water and small solutes pass
- Animals
  - **Tight junctions**
    - Tight seals that prevent leakage
  - **Desmosomes**
    - Anchoring junctions
  - **Gap junctions**
    - Communicating junctions

Unit 2
Cells

Chapter 5: Membrane Transport and Cell Signaling

Cell Membrane

- Plasma membrane separates cell from its surroundings
- Consists primarily of phospholipids and proteins
- Exhibits **selective permeability**, allowing some substances to cross it more easily than others
  - Hydrophobic (nonpolar) molecules can cross easily
    - Ex: Hydrocarbons, carbon dioxide, oxygen
  - Ions and polar molecules, such as sugars, which are hydrophilic do not cross the membrane easily

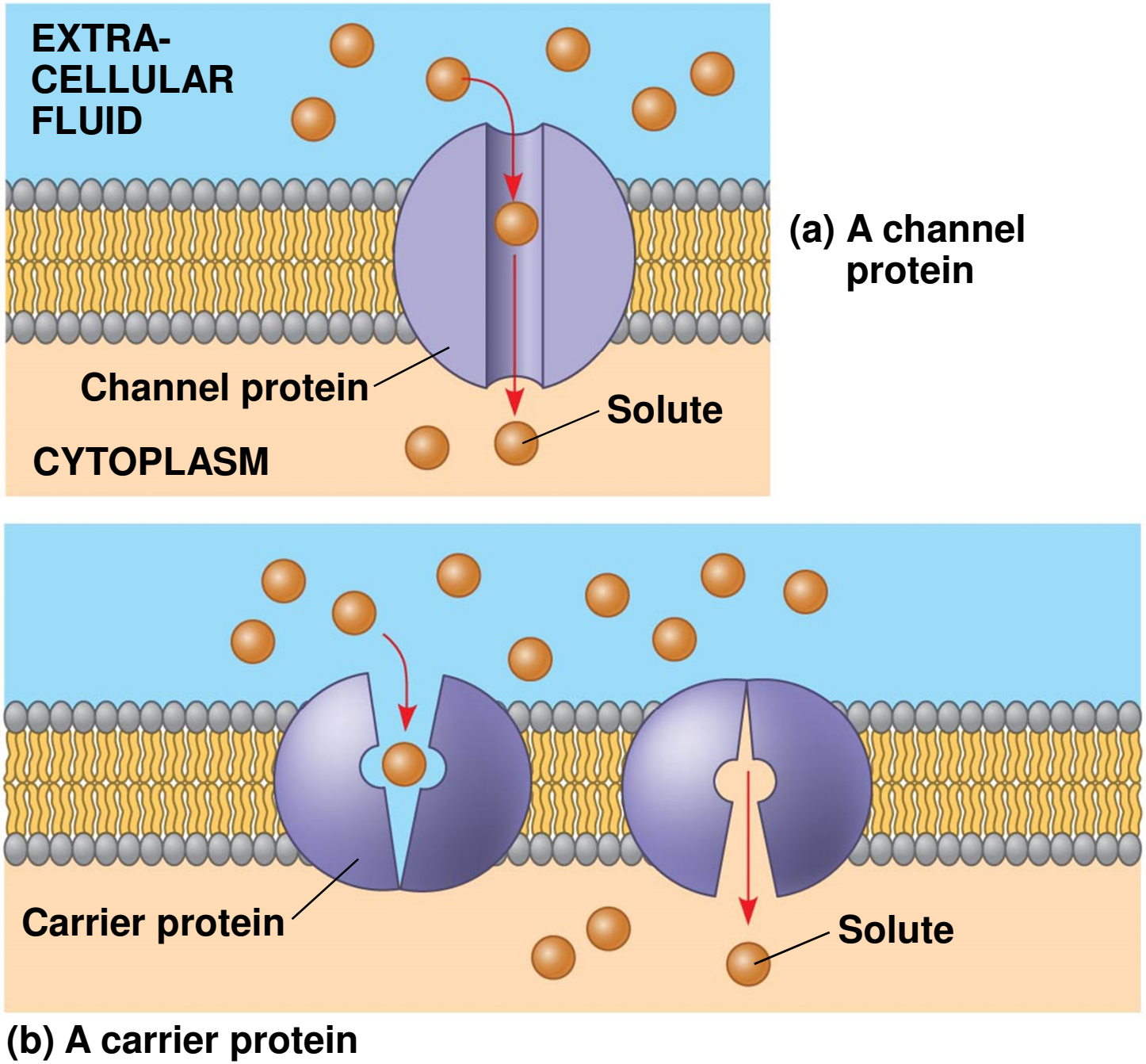
- **Transport proteins** allow passage of hydrophilic substances across the membrane
  - **Aquaporins** facilitate the passage of water
  - C*hannel proteins*
  - C*arrier proteins*
- A transport protein is specific for the substance it moves

Passive Transport

- **Passive Transport**
  - High to low (down concentration gradient)
  - No energy needed
  - Ex: **Diffusion**
    - Substance moves from high to low concentration
    - At dynamic equilibrium, as many molecules cross the membrane in one direction as in the other

- In **facilitated diffusion**, transport proteins speed the passive movement of molecules across the plasma membrane
  - Still high to low but with the help of a protein
  - No energy input needed
- Transport proteins are very specific!
  - They transport some substances but not others

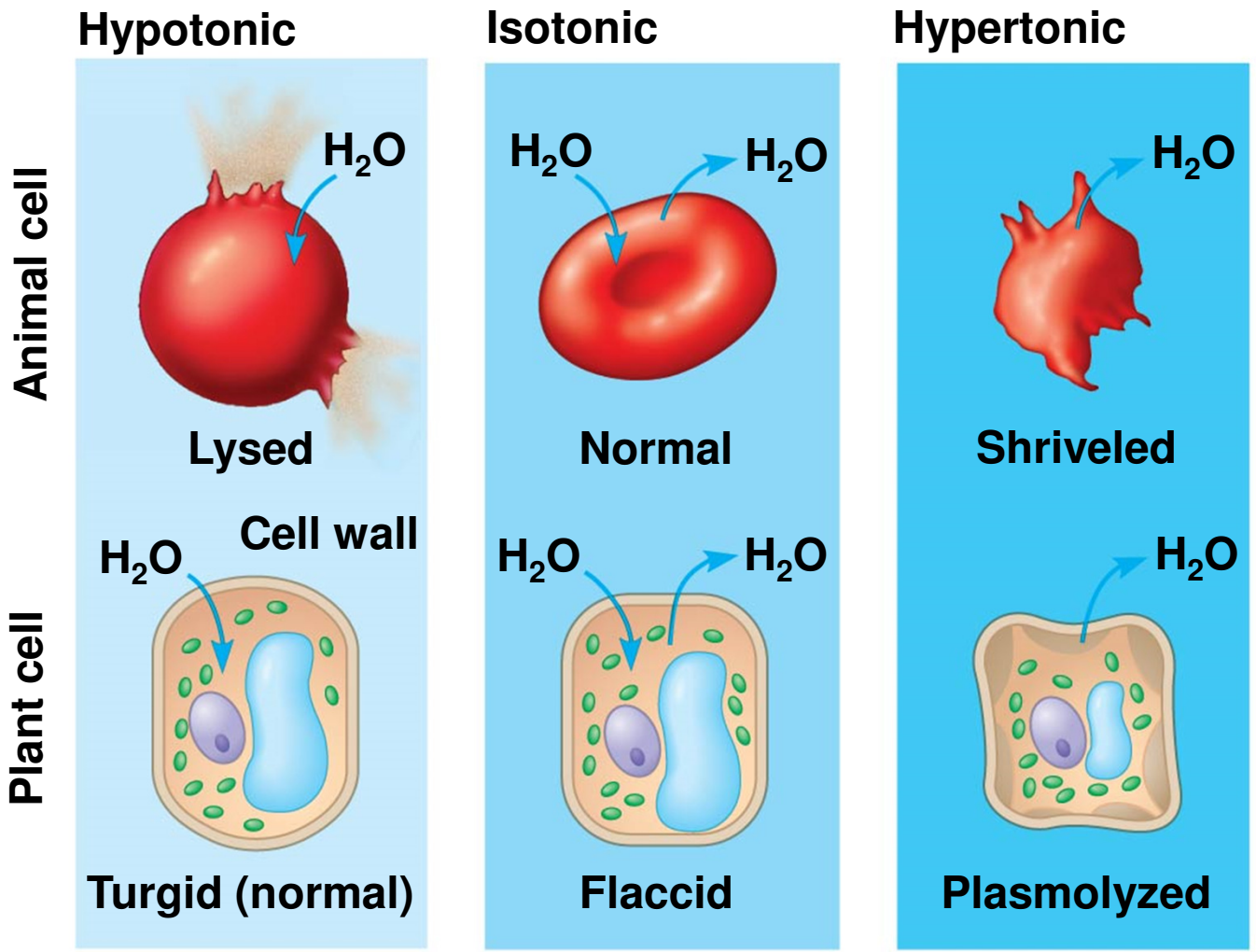
Figure 5.13


EXTRA-
CELLULAR
FLUID
Channel protein
Solute
CYTOPLASM
(a) A channel protein
Carrier protein
Solute
(b) A carrier protein

- **Osmosis** is the diffusion of free water across a selectively permeable membrane
  - From the region of lower solute concentration
    - Which has a higher free water concentration
  - To the region of higher solute concentration
    - Which has a lower free water concentration

- **Isotonic** solution
  - Solute concentration is the same as inside the cell
  - No net water movement across the plasma membrane
- **Hypertonic** solution
  - Solute concentration is greater than that inside the cell
  - Cell loses water
    - Animal cell: Crenation (cell shrivels/shrinks)
    - Plant cell: Plasmolysis (leads to plant death)
- **Hypotonic** solution
  - Solute concentration is less than that inside the cell
  - Cell gains water
    - Animal cell: Lysis (cell ruptures)
    - Plant cell: Turgid (normal)

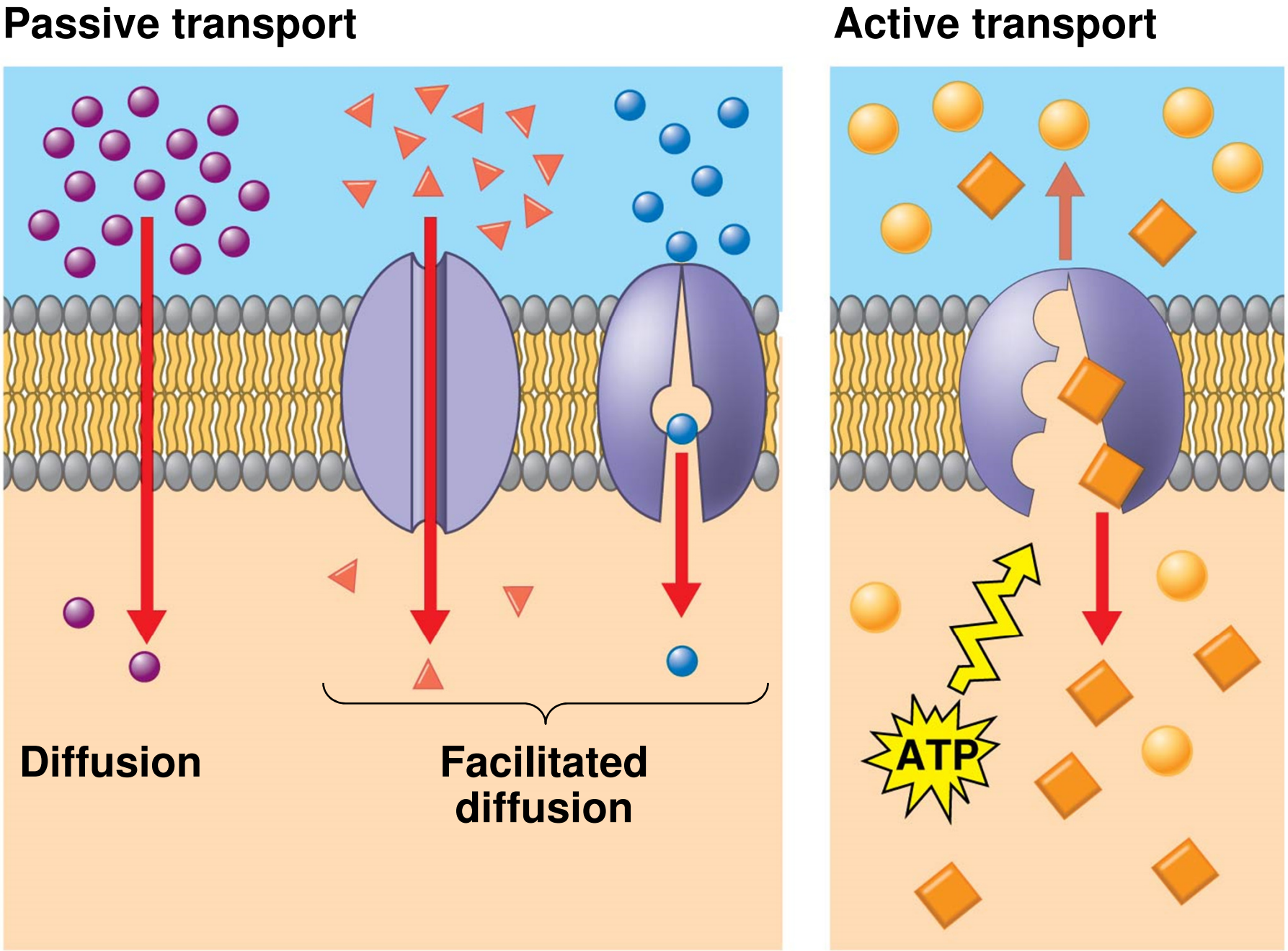
Figure 5.11


Hypotonic
Isotonic
Hypertonic
Animal cell
Plant cell
H_2O
Lysed
Normal
Shriveled
Cell wall
Turgid (normal)
Flaccid
Plasmolyzed

Active Transport

- **Active transport**
  - Moves substances *against* their concentration gradients
  - Requires *energy*, usually in the form of ATP
  - Ex: **Sodium-potassium pump**
    - Higher concentration of potassium ions (K+) inside cell
    - Lower concentration of sodium ions (Na+) inside cell
      - 3 Na+ ions are moved out of cell for every 2 K+ pumped into cell

Figure 5.15

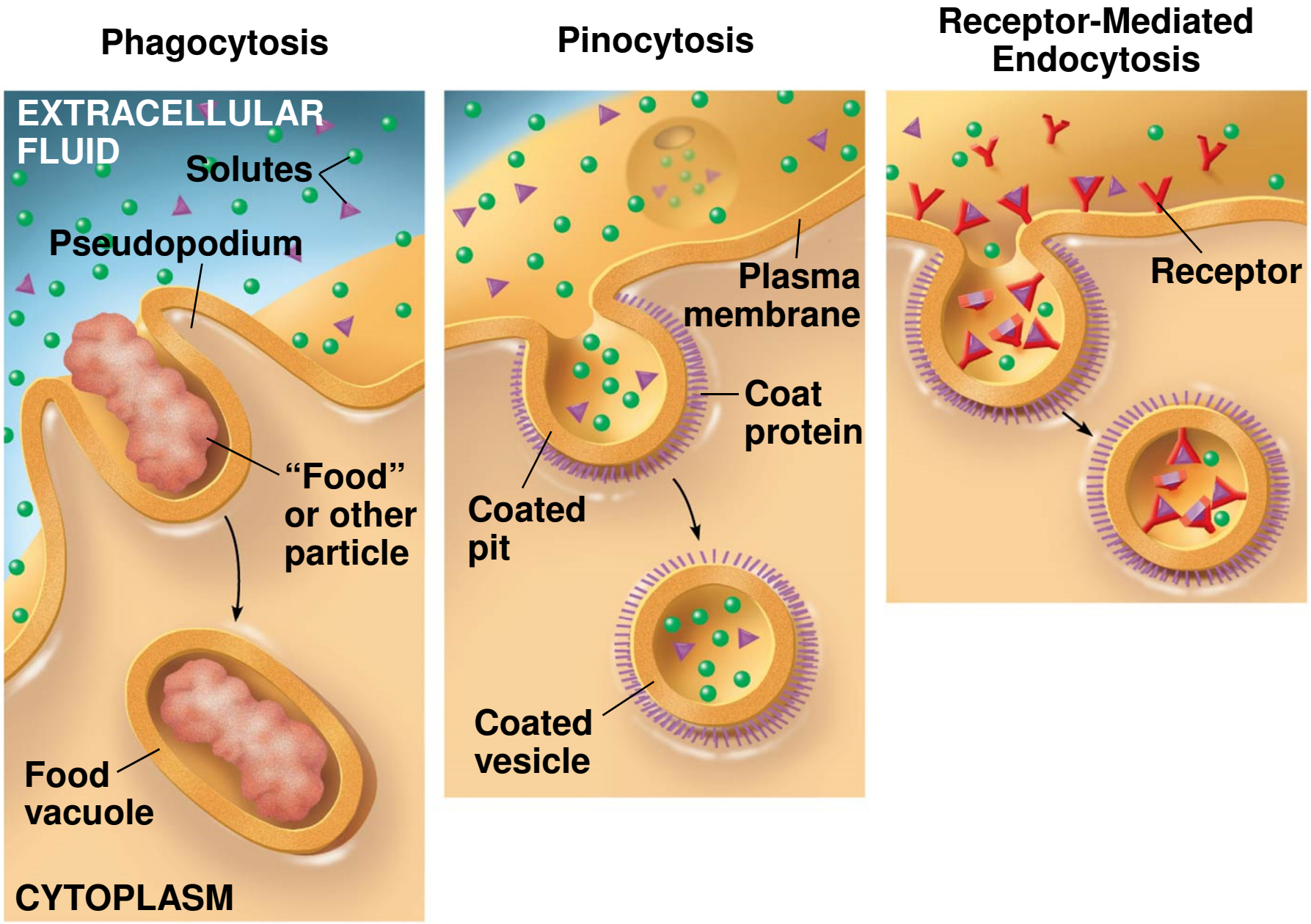

Passive transport
Active transport
Diffusion
Facilitated diffusion
ATP

Bulk transport

- Bulk transport requires energy
- **Exocytosis**, transport vesicles migrate to the membrane, fuse with it, and release their contents
  - EXIT
  - Many secretory cells use exocytosis to export products (like insulin or neurotransmitters)
- **Endocytosis**, the cell takes in molecules and particulate matter by forming new vesicles from the plasma membrane
  - IN

- Endocytosis is a reversal of exocytosis, involving different proteins
- There are three types of endocytosis
  - **Phagocytosis**
    - “Cellular eating”
  - **Pinocytosis**
    - “Cellular drinking”
  - **Receptor-mediated endocytosis**
    - Specialized type of endocytosis that enables cells to acquire bulk quantities of specific substances

Figure 5.18

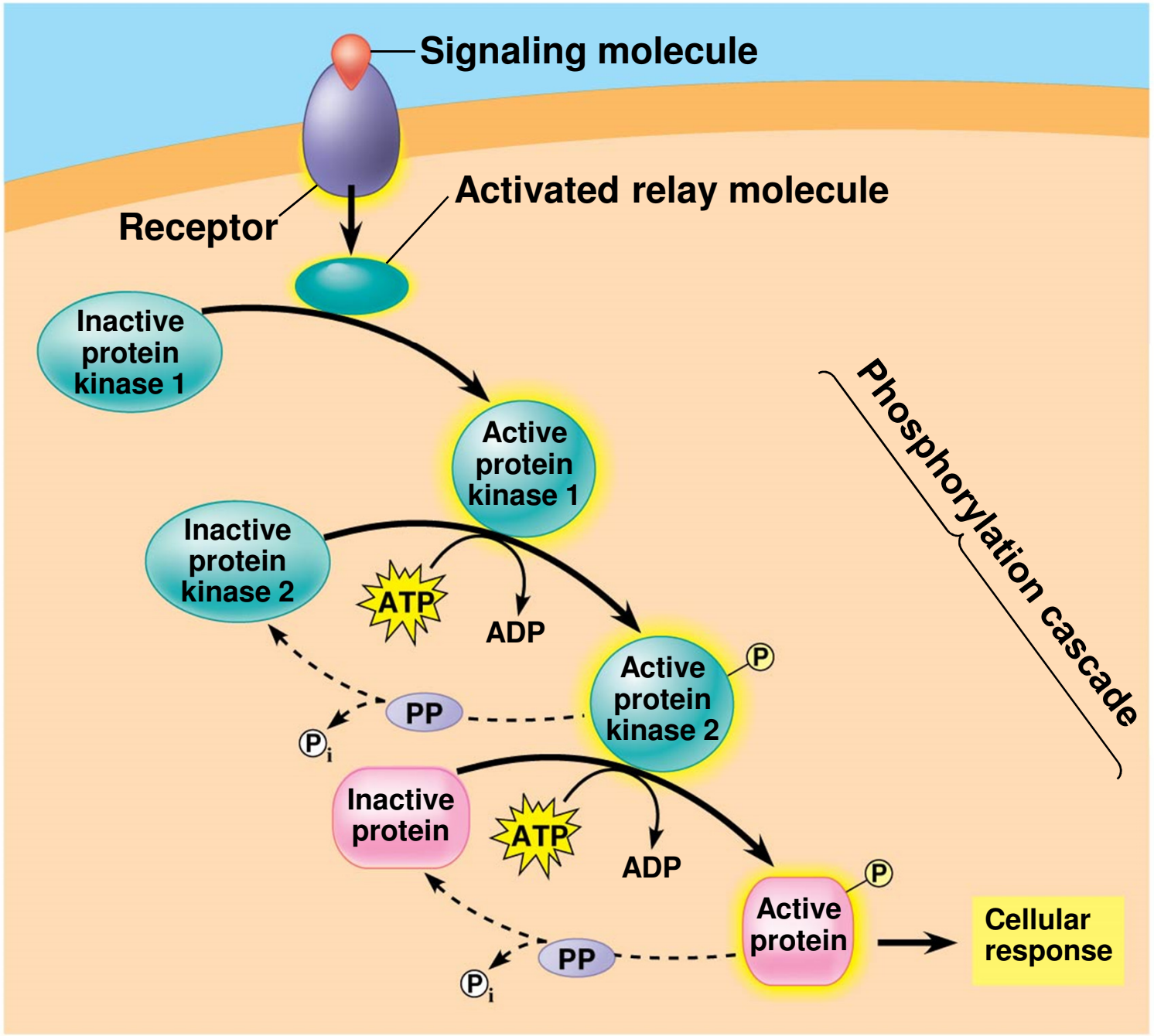

Phagocytosis
Pinocytosis
Receptor-Mediated Endocytosis
EXTRACELLULAR FLUID
Solutes
Pseudopodium
"Food" or other particle
Food vacuole
CYTOPLASM
Plasma membrane
Coat protein
Coated pit
Coated vesicle
Receptor

Cell Signaling

- Junctions that directly connect the cytoplasm of adjacent cells
  - Animal cells-gap junctions
  - Plants cells-plasmodesmata
- The free passage of substances in the cytosol from one cell to another is a type of local signaling (short distance)
  - Ex: growth factors, paracrine signaling, synaptic signaling
- In long-distance signaling, plants and animals use chemicals called **hormones**
  - Ex: endocrine signaling

- 3 stages of cell signaling
  - **Reception**
    - Target cell's detection of a signaling molecule (**ligand**) coming from outside the cell
  - **Transduction**
    - Steps that convert the signal to a form that can bring about a specific response
    - Can amplify a signal
    - Phosphorylation and dephosphorylation
  - **Response**
    - Change in activity brought about by transduced signal
    - May turn genes on and off

Figure 5.24


Signaling molecule
Receptor
Activated relay molecule
Inactive protein kinase 1
Active protein kinase 1
Inactive protein kinase 2
ATP
ADP
Active protein kinase 2
P
PP
Pi
Inactive protein
ATP
ADP
Active protein
P
PP
Pi
Cellular response
Phosphorylation cascade